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Forest Health Protection

Pacific Southwest Region

Date: December 27, 2001
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To: District Ranger, Nevada City Ranger District, Tahoe National Forest

Subject: Monitoring Report: Columbo Prescribed Fire (NE01-03)

Background and Need

Prescribed fire is a routine under-story treatment on National Forest lands throughout the western United States. It is used to reduce potential fuel loads; prepare areas for regeneration; and create and maintain wildlife habitat. The interaction of bark beetles in wildfire injured trees has been reported by various authors (Show and Kotok 1924, Miller and Patterson 1927, Miller and Keen 1960, Furniss 1965, Rasmussen et al. 1996) however there is little information available regarding how bark beetles will operate in stands burned by prescribed fires. Further study is needed for Forest Health Protection personnel to provide accurate input to National Environmental Policy Act (NEPA) analysis regarding the possibility of post-prescribed fire mortality resulting from bark beetle attacks.

This study was part of the Columbo prescribed fire project on the Nevada City Ranger District of the Tahoe National Forest (T18N. R9E. Sec. 22-24) It initiated to provide information regarding bark beetle activity and fire-related mortality following prescribed fires in mixed conifer forests, and to assess differences in bark beetle activity between areas burned in the spring and fall. The project area covered 1250 acres, with elevations ranging from 2400 to 4000 feet, and annual precipitation of 56 to 60 inches. Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), incense cedar (*Libocedrus decurrens*), ponderosa pine (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*) and California black oak (*Quercus kelloggii*) make up the overstory. Understory shrubs include dogwood (*Cornus sp.*), deer brush (*Ceanothus sp.*) and manzanita (*Arctostaphylos sp.*).

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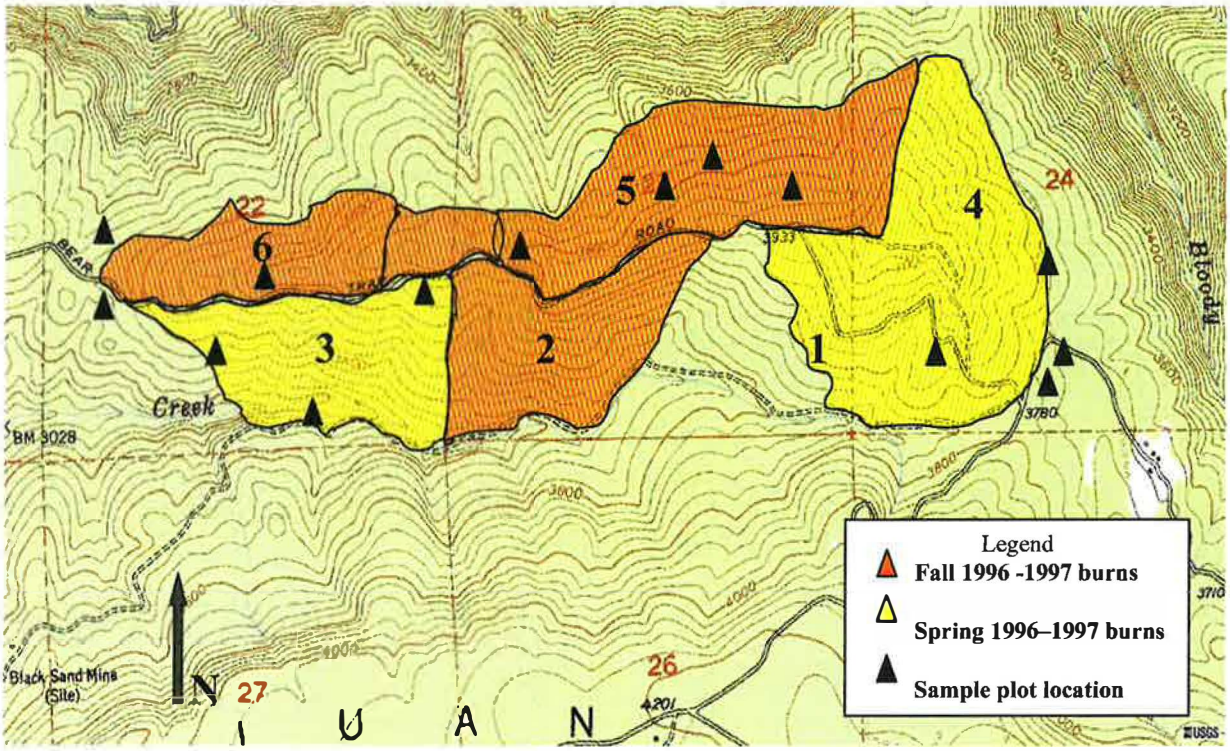
Figure 1. Columbo prescribed fire phases 1-6 (T18N. R9E. Sec. 22-24).



The Columbo prescribed fire project objectives were to: 1) re-introduce fire into the ecosystem, 2) open up the area for deer migration, 3) keep canopy layers intact for Spotted Owl habitat, and 4) lower fuel loads to reduce fire hazard ratings.

The fire was accomplished in six phases starting in June of 1996. District personnel established three 50-200 acre units to be burned in the spring or fall (Figure 1). Forest Health Protection and District personnel installed five (1/3 acre) monitoring plots in each of the burned areas and in adjacent unburned control areas. Plots were visually rated by District personnel as to the intensity of the burn (light, moderate, and high) based on the amount of basal scorching and ground char present. Information collected on each plot included general stand data and data for each individual dead tree. Data collected from 1997 through 2001 for dead trees included: number, species, diameter at breast height (DBH) and the cause of death (fire injuries or bark beetles).

Assessing tree Mortality

Each tree within the monitoring plots was visually assessed annually. Any tree lacking green foliage was classified as dead. Dead trees were divided into two categories: 1) mortality caused by fire, or 2) mortality caused by bark beetles. Because tree mortality caused by insects, diseases and fire are typically interrelated, it was often difficult to assign a single cause of death. For this study any dead tree with signs of attacks (e.g. successful pitch tubes, boring frass, galleries and exit holes) by the mountain pine beetle (*Dendroctonus ponderosae*), western pine beetle (*Dendroctonus brevicomis*), Douglas-fir beetle (*Dendroctonus pseutotsugae*), or fir engraver (*Scolytus ventralis*) were recorded as bark beetle caused mortality. Dead trees with fire injuries and no visible signs of successful bark beetle attack were recorded as fire killed.

Monitoring Results

Fire

As is typical with all fires, burn intensity in the Columbo area varied based on localized fuels, terrain, and weather conditions. The fire created a mosaic pattern of green unburned trees and shrubs to areas of heavy crown and basal scorching with complete shrub consumption. Fire caused conifer mortality was concentrated in the spring plots (Tables 1 and 2) with a loss (all plots) of 66 trees (>6" DBH) compared to four trees (>6" DBH) in the fall burned plots. Spring plots were rated as high or moderate intensity. Three of the five spring plots were rated as high intensity with half of the total mortality occurring in one plot. Fall plots were rated as low or moderate intensity and burned more evenly than the spring plots. Most fire caused mortality was recorded during 1997 with a few additional trees dying in 1998. No fire caused mortality has been recorded on any spring or fall burned plot since 1998.

Table 1. Fire caused mortality by species and year for the spring burned plots.

	Year				
Species+	1997	1998	2000	2001	Totals
PP	22	1	0	0	23
DF	14	6	0	0	20
SP	12	4	0	0	16
WF	7	0	0	0	7

+ PP-ponderosa pine, DF- Douglas fir, SP-sugar pine, WF-white fir

Table 2. Fire caused mortality by species and year for the fall burned plots.

	Year				
Species+	1997	1998	2000	2001	Totals
PP	0	1	0	0	1
DF	0	0	0	0	0
SP	0	0	0	0	0
WF	0	2	0	0	2
IC	0	1	0	0	1

+ PP-ponderosa pine, DF- Douglas fir, SP-sugar pine, WF-white fir

Fire caused mortality in the spring plots occurred in all size classes with the majority (39%) occurring in the 6-10" DBH size class followed by 30% in the 10-16" DBH size class (Table 3). Nine trees died in the 20-30" DBH size class equating to an average loss of 5.4 trees >20" DBH/acre in the spring plots. Mortality in the fall plots occurred in only the smaller size classes with the four trees all being <16" DBH (Table 4). Most trees <6" DBH were consumed on all plots.

Table 3. Fire caused mortality by species and size class for the spring burned plots.

	Species+				
DBH	PP	SP	DF	WF	Totals
6-10"	8	3	10	5	26
10-16"	8	7	4	1	20
16-20"	3	4	3	1	11
20-30"	4	2	3	0	9

+ PP-ponderosa pine, DF- Douglas fir, SP-sugar pine, WF-white fir

Table 4. Fire caused mortality by species and size class for the fall burned plots.

	Species+				
DBH	PP	SP	WF	IC	Totals
6-10"	1	0	1	1	3
10-16"	0	0	1	0	1
16-20"	0	0	0	0	0
20-30"	0	0	0	0	0

+ PP-ponderosa pine, DF- Douglas fir, SP-sugar pine, WF-white fir

Bark beetles

All bark beetle caused mortality occurred in 2000 (Table 5), 3-4 years post-fire and was restricted to ponderosa pine and sugar pine in the high intensity spring plots. No bark beetle caused mortality was recorded in the fall burned or control plots. Bark beetles found in the high intensity spring burned plots included the western pine beetle in ponderosa pine and mountain pine beetle in sugar pine. Red turpentine beetle (RTB), *Dendroctonus valens*, pitch tubes were also found at the base of two of the beetle-killed trees. The attacks by RTB encompassed >80% of the bole circumference on those two trees.

Table 5. Bark beetle caused mortality by species and year for the spring plots.

	Year				
Species+	1997	1998	2000	2001	Totals
PP	0	0	8	0	8
DF	0	0	0	0	0
SP	0	0	2	0	2
WF	0	0	0	0	0

+ PP-ponderosa pine, DF- Douglas fir, SP-sugar pine, WF-white fir

Although bark beetle caused mortality was low overall in terms of numbers of trees, the number of large trees that were killed in each plot compared to the total number of large trees within each plot may be a cause of concern depending upon management objectives. All mortality caused by bark beetles occurred in trees larger than 18" DBH with 80% of the total number being in the >20" DBH size class (Table 6). Combining the additional eight bark beetle killed trees (>20"DBH) with the nine fire killed trees (>20"DBH) equates to10.3 large dead trees/acre in the spring burn plots.

Table 6. Bark beetle caused mortality by species and size class for the spring plots.

	Species+				
DBH	PP	SP	DF	WF	Totals
6-10"	0	0	0	0	0
10-16"	0	0	0	0	0
16-20"	2	0	0	0	2
20-30"	3	1	0	0	4
30"+	3	1	0	0	4

+ PP-ponderosa pine, DF- Douglas fir, SP-sugar pine, WF-white fir

Discussion

Tree death due to fire injuries and mortality caused by bark beetle attacks is very difficult to predict when analyzing the potential effects of prescribed fires. This study shed some light on what may be expected in terms of tree mortality given similar species composition, stand structure, season of burn and fire behavior. Fire caused mortality of trees >6" DBH was higher in the spring burned plots compared to the fall burned plots. This is consistent with other reported effects of prescribed burning that compared mortality rates and season of burn (Harrington 1987; Swezy and Agee 1990). Many researchers suggest that seasonal differences in mortality are best explained by bud phenology (Wagener 1961; Dieterich 1979; Wyant et al. 1983; Harrington 1987). Dieterich (1979) also attributed greater mortality in early season burns to seasonal differences in tissue moisture content and ambient temperature. Spring burns

typically occur during the most active growing period for many plants, and the ability of these plants to recover is reduced because carbohydrate reserves are lower during that period. Crown damage is typically most severe in spring and early summer burning due to the low foliar moisture content and the succulent nature of the buds and twigs (Wagener 1961).

Delayed mortality from fire injury may continue for several years post-fire or may not become apparent until a few years after a fire. To date, in this study all fire related mortality occurred within the first 2 years post-fire. Delayed mortality due to cambium scorch was observed in 2000 at Lava Beds National Monument in ponderosa pine where prescribed fires had been conducted three years earlier (Smith 2000a). We commonly observe extensive (in terms of tree circumference) cambium damage where the layer of phloem cells under the bark is killed but water is still being conducted upward to the crown through the undamaged xylem cells in the sapwood. This continued water transport to the crown may enable the tree to remain green for a few years, however, the inability of the phloem to conduct carbohydrates downward to the roots results in slow starvation and death.

Many of the trees that succumbed to fire injuries were in the larger size class (>20"DBH) and were ponderosa pine, sugar pine or Douglas-fir. The death of large trees due to fire injuries likely contributed to a reduction in canopy cover which may be a concern depending upon management objectives and the extent of the prescribed fire project that experienced similar levels of mortality. Ponderosa pine are considered very fire resistant, sugar pine are intermediate in fire tolerance and the thicker bark of older Douglas-fir makes them fairly resistant to ground fires (Burns & Honkala 1990). The fact that several of the large trees in this study died due to fire-injuries indicates that either their crowns were consumed or there was extensive root or cambium damage. Extensive root or cambium damage can occur on older trees with thick bark if litter and duff accumulations are such that fires smolder at the base of trees for an extended period of time or fire intensity is increased due to the fuels at the base of the tree. The unprecedented litter and duff accumulations observed in most western forests are well documented and described by various authors (Sackett and Haase 1991, 1998; Sackett et al. 1996; Haase and Sackett 1998; and Covington et al.1997) and should be of concern when using prescribed fire in areas where large tree retention is desirable.

The ability to predict mortality caused by bark beetles killing fire-injured trees in subsequent years remains difficult. We can summarize from this study that bark beetles were most active in the plots burned in the spring and in the plots rated as high intensity. Attacks occurred 3-4 years after the fires which can be attributed to a combination of the trees being weakened from fire injuries and a decline in precipitation levels which enabled the beetles to successfully attack weakened trees. Most bark beetle caused tree mortality occurred in pine trees >20"DBH. As mentioned above, the consequence of burning around trees with large accumulations of litter and duff can cause extensive damage to fine roots and/or cambial layer resulting in an increase in susceptibility to bark beetle attacks. In addition, it is common for mountain pine beetles to attack injured sugar pines and fire injured trees are no exception (Schultz 1989; Smith 2000b; Smith 2000c). Land managers who conduct prescribed fires in areas with sugar pine can expect an increase in mortality due to attacks by mountain pine beetle and should take measures to ensure that sugar pine desired for retention are protected from fire injury.

This monitoring study was limited in scope and size but provided us with useful information and insight on how to improve future studies. More in-depth studies are needed to address the short and long-term effects of prescribed fire on tree physiological condition, and the relationship

between fire injuries and bark beetles under various stand conditions, compositions and burn seasons.

If you have any questions regarding this report please call any of the Entomology staff at 530-257-2151.

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